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Nobel Prize in Chemistry 1961

Melvin Calvin

The Nobel Prize in Chemistry 1961 was awarded to Melvin Calvin *"for his research on the carbon dioxide assimilation in plants"*.

RESEARCH INFORMATION:

In order to grow and to perform its various activities, every living organism needs a supply of energy in some suitable form. In this respect the organisms existing on this planet can be divided into two fundamentally different groups. All animals, including man, and also some lower organisms, require a supply of energy-rich organic material, food-stuffs that "contain calories", to use a popular expression. The energy contained in the food-stuffs is made available by a biological oxidation ("combustion") of carbohydrates, fats, etc. Obviously, these types of organisms, the so-called heterotrophic organisms, are absolutely dependent on supplies of organic material, occurring outside themselves.

As opposed to the heterotrophic organisms, the organisms belonging to the second group, the so-called autotrophic organisms, i.e. the green plants and certain bacteria, do not require organic material supplied from without. They synthesize organic compounds, primarily carbohydrates, from simple substances, carbon dioxide and water, substances that, in themselves, do not contain any calories. The energy needed for the synthesis is supplied by light which is absorbed by the organisms and subsequently converted by them from light energy into chemical energy. The sequence of reactions by which carbon dioxide and water are converted to carbohydrate is called carbon dioxide assimilation or, taking into account the role of light energy, photosynthesis.

It becomes obvious that photosynthesis not only provides an explanation for the existence of the autotrophic organisms but also furnishes food for man and animals. In other words, photosynthesis is the absolute prerequisite for all life on earth and the most fundamental of all biochemical reactions. It has been estimated that plants and microorganisms on earth transform about 6,000 tons of carbon from carbon dioxide to carbohydrate per second, with at least four-fifths of this amount contributed by organisms in the oceans.

It is understandable that a reaction of such importance and such dimensions should attract the interest of science at an early stage. For more than a century, however, progress in the understanding of the chemistry of photosynthesis was very slow, partly for want of suitable experimental methods.

More than fifty years ago it was recognized that photosynthesis comprised two distinct phases, light reactions and dark reactions. The Nobel Laureate today, Dr. Melvin Calvin, has spent many years of research work on the chemistry of both phases of photosynthesis and, in the case of the second phase, that is to say the reactions leading from carbon dioxide to the assimilation products - to quote Calvin, "the path of carbon in photosynthesis" his work has resulted in the complete clarification of an extremely intricate problem.

Success was achieved as a result of sharp-witted, skilful and persistent work, to some degree facilitated by the availability of certain modern experimental methods that allow investigations which, in older times, were simply impossible. Two such methods may be mentioned: the method of the isotopic labeling of molecules, introduced by de Hevesy, and the chromatographic methods, developed by Martin and Synge, which permit the separation of minute quantities of compounds in complicated mixtures. By an ingenious

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combination of these and many other methods, Calvin succeeded in tracking the path of the carbon atom from carbon dioxide, taken up by the plant, to the finished assimilation products. The radioactive carbon isotope, ^{14}C well-known also in other connections, has played a particularly important role in Calvin's work.

Most of Calvin's experiments have been performed using a microscopic green alga, *Chlorella pyrerloidosa*, but parallel experiments with higher plants have shown that the mechanism of carbon dioxide assimilation is the same in all plants.

A question that had occupied scientists for more than a century, was: "What is the primary product of the assimilation; what first happens to the carbon dioxide taken up by the plant?" Calvin demonstrated that the primary reaction is not, as had been assumed previously, a reduction of carbon dioxide as such, but a fixation of carbon dioxide to a substance, the carbon dioxide acceptor, occurring in the plant. Calvin was able to show that the product formed in this fixation reaction is an organic compound known as phosphoglyceric acid.

This discovery was of fundamental importance for the development that followed. The primary product of assimilation was recognized as being a compound, well-known from earlier work as an intermediary product of the biological degradation of carbohydrates, and not some previously unknown compound; phosphoglyceric acid had been identified as a breakdown product of sugar as early as 1929 by Ragnar Nilsson here in Stockholm. Calvin's identification of the primary assimilation product with phosphoglyceric acid led to the very important conclusion that there is an intimate connection between photosynthesis and carbohydrate metabolism as a whole.

Calvin's subsequent investigations mapped out the path between the primary product and the end products of assimilation, the various carbohydrates. What had formerly been assumed to be a reduction of carbon dioxide was shown to be a reduction of phosphoglyceric acid. For a reduction of phosphoglyceric acid to the carbohydrate level, the plant has to supply both a reducing agent and a so-called energy-rich phosphate. It is for the production of these co-factors that plants utilize light energy. This means that light

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energy is not directly involved in the reactions of assimilation; light energy is used for regeneration of co-factors which are consumed in the assimilation reactions.

As mentioned above, the primary reaction in the assimilation is a fixation of carbon dioxide to an acceptor, the chemical nature of which has been established by Calvin. Rather unexpectedly, this acceptor was found to be a derivative of a sugar, ribulose, to which nobody had paid much attention previously. When carbon dioxide is fixed to the ribulose derivative, phosphoglyceric acid is formed.

As the acceptor is consumed during the fixation reaction it must obviously be regenerated from the assimilation products. Calvin has elucidated the very complicated mechanism of this regeneration. Between the primary product and the acceptor there are no less than ten intermediary products and the reactions between these products are catalyzed by eleven different enzymes.

Professor Melvin Calvin. Your investigations on plant photosynthesis have shed light on a field of biochemistry which was, until recently, veiled in obscurity. You have tracked the various steps of the path of carbon in photosynthesis and created a clear picture of this complicated sequence of reactions, reactions of immense importance for life on our planet. On behalf of the Royal Academy of Sciences, I extend to you our warm congratulations, and ask you to receive this year's Nobel Prize for Chemistry from the hands of His Majesty the King.

For more details please visit:

http://www.nobelprize.org/nobel_prizes/chemistry/laureates/1961/press.html